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(54) Compositions with enhanced penetration.

(57) The penetration of various drugs through living membranes is improved by their use in transdermal compositions containing certain penetration-enhancing systems.

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## COMPOSITIONS WITH ENHANCED PENETRATION

Diphenhydramine, hydrochloride (Benadryl®, or 2-(diphenylmethoxy) N, N-dimethylethylamine), is known to be useful for its antihistaminic, anticholinergic, antitussive, antiemetic, and sedative properties. The compound and its preparation are described in US Patent 2,241,714.

The base is a liquid and its salts have acceptable solubilities in standard liquid media. Thus, diphenhydramine-based drugs are conventionally used in dosage forms such as oral and parenteral. However, there are undesirable digestive side effects possible with oral formulations. Generally there are compliance problems with parenterals.

Diphenhydramine is a nonprescription drug widely used alone or in combination with other drugs as an effective antihistamine with a sedative side effect. Carruthers, et al (Clin Pharmacol Ther 1978; 23:375-382) showed that the sedative side effect of diphenhydramine hydrochloride could be eliminated if the blood concentration remains in the range of 25 to 50 ng/ml (equivalent to 21.9 to 43.9 ng/ml diphenhydramine base). This indicates that a sustained dosage form which could provide such constant blood levels would be a very useful and viable dosage form in the treatment of allergy.

Tetrahydroaminoacridine, 1,2,3,4-tetrahydro-9-acridinamine Tacrine, THA), a very old compound is known to be useful as a respiratory stimulant and has anticholinesterase activity. It has been shown that THA improves the amnesia characteristic of Alzheimer's disease (Brinkman and Gershon, 1983; Flood et al, 1985; Rathman and Conner, 1984; McGeer, 1984).

Taziflyline is known to be useful as an antihistamine. It is covered in US Patent 4,374,835.

Atenolol, 4-(2-hydroxy-3-[(1-methylethylamino)propoxy]benzeneacetamide, is covered in US Patents 3,863,607 and 3,836,871. It is a  $\beta$ -adrenergic blocker.

2-Methoxy-4-[2-(5-methyl-1H-pyrazol-3-yl)ethenyl]phenol is covered in pending application 861,179. It has antiasthma, antiallergy, antiinflammatory, antipsoriatic, analgesic, and cardiovascular activities.

While the above drugs are highly efficacious, their use is subject to such problems as dose dumping and high drug use requirements. United States Patent No. 4,811,008 discloses the use of neutral oils like Miglyol®-812 or Miglyol®-829 in a coronary-active gel-containing preparation. Miglyol® is a mixture of triglycerides containing saturated plant fatty acids of a chain length of  $C_8$  to  $C_{12}$  (Angewandte Biopharmazie, Wiss. Veri.Ges. Stuttgart 1973, p. 314).

United States Patent No. 4,331,851 covers in part, caprylic/capric acid -1,2-propanediol diester used as a release-promoting substance used in a silicone rubber carrier for an active ingredient.

United States Patent No. 4,336,243 covers a microsealed transdermal delivery pad for nitroglycerin administration which contains a silicon matrix having microsealed compartments of silicone rubber mixed with a hydrophilic solvent system, the solvent system can contain a saturated coconut oil such as miglyol® oil which improves the transport and absorption of the nitroglycerin.

It has been discovered that therapeutically active agents such as diphenhydramine, tetrahydroaminoacridine, atenolol, taziflyline, 2-methoxy-4-[2-(5-methyl-1H-pyrazol-3-yl)ethenyl]phenol, and the like in combination with a solvent Miglyol® oil, especially Miglyol® B40, which is a propylene glycol diester of saturated vegetable fatty acids of chain length  $C_8$  to  $C_{10}$  and if desired a gelling agent such as silicic acid (Aerosil® 200) have a higher flux value than formulations without Miglyol® oil when applied on skin. Aerosil® consists of amorphous spheric particles of silicic acid prepared by hydrolysis of Silicon tetrachloride.

Gastrointestinal problems associated with some drugs which are administered orally are thus eliminated. The gradual release of a drug via a membranous tissue minimizes the risk of dose dumping and other side effects.

In addition, the use of the present invention would result in a reduction in overall drug load dose. Furthermore, a patch or other transmembranous device serves as a reminder to the patient to administer the proper dosage.

These and other advantages of the invention will become apparent upon consideration of the following description of the invention.

In a preferred embodiment of the instant invention, a transmembranous composition of diphenhydramine or a pharmaceutically acceptable salt thereof is combined with Miglyol®, a gelling agent and an alcohol in the form of a gel. The gel would be on a controlling or a noncontrolling membrane compatible with manufacturing processes and capable of providing the desired flux of the active ingredient. Microporous membranes, silicone-membranes (Silastic®), and/or polyurethane (with polyester or polyether backbone) membranes among others may be used.

The side effects often associated with the use of diphenhydramine in oral and parenteral formulations

can be overcome by administration of the drug via topical application to body membranes for absorption into the system.

Transdermal delivery systems are not always efficacious due to such factors as the failure of the drug to sufficiently penetrate the cutaneous membrane and enter the body to produce therapeutic systemic effects. The present invention uses a novel penetration enhancer to deliver efficacious amounts of the desired drug to the body. The compositions and methods of the instant invention have several advantages over conventional systems for the delivery of drugs. One principal advantage concerns the undesirable side effects associated with administration via dosage forms which are swallowed or injected. For instance, the nausea and/or other gastrointestinal discomfort associated with liquids and solids which are swallowed is eliminated when transmembrane administration is employed. The compositions of the instant invention are introduced into the body via various membranes, for example, transdermally, buccally, rectally, and nasally.

Also, the storage and transportation problems associated with liquid dosage forms are generally eliminated when transmembrane administration is employed. These are usually creams, gels, and solid suppositories. In the compositions of the instant invention the topical delivery of the drugs has several advantages. One such is the gradual release of the drug via membranous tissue, for example, on the skin or in the nasal passages, minimizes the risk of dose dumping and can also reduce the overall drug loading dose. Also, a patch or other transdermal device serves as a reminder to the patient to administer the proper dosage of the drug.

These and other advantages of the invention will be apparent upon the following description of the invention.

The present invention concerns a composition for use in transmembrane administration of drugs. Such a composition comprises

- (a) about 0.1% to about 50% by weight of one or more drugs selected from the group consisting of diphenhydramine, tetrahydroaminoacridine, atenolol, tazifilina, 2-Methoxy-4-[2-(5-methyl-1H-pyrazol-3-yl)-ethenyl]phenol and the like and the pharmaceutically acceptable salts thereof,
- (b) up to about 99.8% by weight of a solvent, and, if desired,
- (c) up to about 15% by weight of a gelling agent and other excipients or diluents as would occur to one skilled in the art.

All percentages recited herein are weight percentages based on total composition weight unless otherwise specified.

The term diphenhydramine and pharmaceutically acceptable salts thereof is intended to include all forms of diphenhydramine and/or its analogs which have medical utility. Thus, diphenhydramine, its hydrochloride salt, and the like are contemplated. Mixtures may also be used.

While the use of a diphenhydramine-based drug is an example of a transmembrane formulation, the use of other beneficial substances is also contemplated. Thus sedatives, tranquilizers, antinflectives, cardiotonics, cognition activators, and the like may be included in the compositions of the invention.

Generally the drug component will comprise about 0.1% to about 50%, preferably about 1 to about 30%, and most preferably about 2 to about 10% by weight of the total composition.

Other components such as alcohol and a gelling agent are also contemplated. A preferred gelling agent is Aerosil® 200.

Aerosil 200 is a very pure silicic acid with a content of  $> 99.8\% \text{ SiO}_2$ ,  $\text{Al}_2\text{O}_3 > 0.05$ ,  $\text{TiO}_2 > 0.03$ ,  $\text{HCl} > 0.01$  and a moisture of about 1.5%. The pH-value of a 4% water dispersion is  $3.9 \pm 0.3$ . The BET-surface is  $200 \pm 25$  and the medium size of the primary particles is  $16 \mu\text{m}$  (Fiedler, Lexikon der Hilfsstoffe für Pharmazie, Kosmetik und angrenzende Gebiete, Editio Cantor KG, Aulendorf i. Würt., 1971, page 20). All acceptable excipients, antioxidants, preservatives, including fatty acid esters as for example hexadecanoic methyl ester of Wicken® 535 and vitamin E.

A controlling membrane is also contemplated. Preferred membranes include microporous membranes, silicone membranes (Silastic®), polyurethane membranes, and the like.

A method of administering the above composition includes (a) contacting the drug with a vehicle to produce a transmembrane formulation and (b) applying that formulation in a suitable device to body membrane for absorption therethrough.

Other conventional adjuncts, for example, colorants, perfumes, stabilizers, and the like can also be employed in compositions of the present invention.

While the use of a diphenhydramine-based drug are essential to the composition, the use of other beneficial substance is also contemplated and may be used in the composition.

The permeation-enhancing portion of the instant invention is a substance which functions to assist in the migration of the drug component(s) through the membranes and into the bloodstream. Thus, any agent(s)

which function to hasten and/or to regulate the transmembranal passage or systemic release of drug(s) can be used in combination with Miglyol 840.

Generally the solvent, the permeation-enhancing component, will comprise about 0.1 to 99.9%, preferably to 80%, and most preferably 50 to 80% by weight of the total composition. The action ingredient permeates through the skin as a neat drug (base) or in formulations containing a solvent.

The solvent component will comprise at least one solvent for the drug component. Useful solvents include but are not limited to Miglyol® oils, alcohol, IPM, and the like. Mixtures of two or more are also usable. Preferably the solvent is Miglyol® 840. The solvent component will comprise about 0.1, to about 99.8%, preferably about 50 to about 80% and most preferably from about 50 to about 70% by weight of the total composition.

The term solvent is intended to include that portion of the formulation which provides the flux of the active ingredient. The preferred solvent is Miglyol® 840 which is a propylene glycol di-ester of caprylic and capric acids from coconut oil.

The following example illustrates one embodiment of the invention. It is not intended to limit the scope of the invention in any way.

The drug-containing gel composition:

| Ingredients          | Percent<br>(%) w/w |
|----------------------|--------------------|
| Diphenhydramine Base | 20.0               |
| Miglyol® 840         | 73.0               |
| Wickanol® 535        | 0.5                |
| Vit. E Alcohol USP   | 0.05               |
| Aerosil® 200         | 6.45               |

Both Silastic® membrane and polyurethane membranes (with polyester or polyether backbone) were evaluated. In addition the effect of the gelling agent Aerosil® 200 on diphenhydramine flux was determined.

Pharmaceutical compositions containing Miglyol® neutral oils are useful in effecting transdermal delivery of a therapeutic dose of an active drug to the system of mammals. Tables 1-5 below show a series of comparative in vitro diffusion studies illustrating the usefulness of Miglyol® oils, e.g., Miglyol® 840 (Dynamit Nobel Chemicals) as effectively enhancing the penetration of different drugs across biological membranes. Hairless mouse skin was used.

Miglyol® neutral oils, e.g., Miglyol® 812, 810, 818, and 840) are esters of medium chain fatty acids also called fractionated coconut oil. Miglyol® 840 is a propylene glycol di-ester of caprylic and capric acids. Miglyol® neutral oils are completely stable against oxidation, tasteless and odorless, soluble in alcohol, nonirritating to the skin.

TABLE I

| Comparison of Miglyol® 840's Effect on the Permeation of Taziflyline with other Skin Permeation Enhancers Across Hairless Mouse Skin |                         |   |              |   |
|--|-------------------------|---|--------------|---|
| Formulation  | Donor Conc.*<br>(mg/ml) | Flux†<br>( $\mu\text{g}/\text{cm}^2/\text{h}$ ) | Lag Time (h) | Permeability‡<br>( $\text{cm}/\text{sec}$ ) $\times 10^7$ |
| LA:PG 10:90  | 6.54                    | 20.48   | 1.2          | 8.70  |
| LA:Miglyol® 840 10:90  | 14.37                   | 33.68   | 8.47         | 6.51  |
| DMSO:H <sub>2</sub> O 80:20  | 5.96                    | 25.08   | 15.97        | 11.69   |
| ETOH:Miglyol® 840 20:80  | 52.13                   | 290.58  | 0.77         | 15.48   |
| LA:PG:TA 20:30:50  | 48.07                   | 104.66  | 8.01         | 6.31  |
| Miglyol®-Gel: Miglyol® 840:ETOH 66.8:26.7:6.7  | 15.08                   | 37.33   | 3.23         | 6.88  |
| DPH:PG 50:50   | 16.3                    | 7.81  | 10.45        | 1.33  |

\* saturated solution  
† Average flux value  
‡ Estimated by dividing flux value by initial drug concentration  
LA = Linoleic Acid  
PG = Propylene Glycol  
DMSO = Dimethyl Sulfoxide  
TA = Triacetin  
ETOH = Ethanol  
DPH = Diphenhydramine

TABLE II

| Effect of Miglyol® 840 on Diphenhydramine (DPH)<br>* Flux Value Across Hairless Mouse Skin |   |                 |
|--|---|-----------------|
| Formulation w/w  | Flux†<br>( $\mu\text{g}/\text{cm}^2/\text{h}$ ) | Lag Time<br>(h) |
| 80:40 Miglyol® 840:DPH   | 132 $\pm$ 21                                    | 0               |
| 70:30 Miglyol® 840:DPH   | 118 $\pm$ 9                                     | 0               |
| 90:10 Miglyol® 840:DPH   | 103 $\pm$ 18                                    | 0.2 $\pm$ 0.2   |
| 95:5 Miglyol® 840:DPH  | 70 $\pm$ 19                                     | 0.3 $\pm$ 0.2   |
| Neat DPH   | 94  | 0               |

† Average flux value

TABLE III

| Effect of Miglyol® 840 on Enhancing the Penetration of PD 123,124 Across Hairless Mouse Skin |                       |   |                 |
|--|-----------------------|---|-----------------|
| Solvent System   | Drug Conc.<br>(mg/ml) | Flux Value†<br>( $\mu\text{g}/\text{cm}^2/\text{h}$ ) | Lag Time (h)    |
| Acetone  | 5                     | 6.46 $\pm$ 2.43                                       | 1.68 $\pm$ 0.67 |
| LA:PG:TA 20:30:50 w/w  | 20                    | 7.1 $\pm$ 5.8   | 2.65 $\pm$ 0.16 |
| Miglyol® 840:ETOH 80:20 w/w  | 10                    | 41.33 $\pm$ 7.88                                      | 2.2 $\pm$ 0.1   |

† Average flux value

TABLE IV

| Skin Penetration Enhancement Effect of Miglyol® 840 on THA as Compared with Other Penetration Enhancers |               |  |                |
|---|---------------|--|----------------|
| Solvent System  | Percent (w/w) | Flux Value† ( $\mu\text{g}/\text{cm}^2/\text{h}$ ) | Lag Time (h)   |
| LA:PG:TA 20:30:50 w/w   | 2             | 168.6 $\pm$ 1.9                                    | 2.9 $\pm$ 1.3  |
| LA:ETOH:H <sub>2</sub> O 5:70:25 w/w  | 4             | 845.6 $\pm$ 87                                     | 6.5 $\pm$ 0.5  |
| DPH:PG 50:50 w/w  | 4             | 102.45 $\pm$ 5.5                                   | 5.1 $\pm$ 0.56 |
| Miglyol® 840:ETOH 80:20   | 4             | 2011.5 $\pm$ 117                                   | 1.3 $\pm$ 0.2  |
| PG  | 4             | 106.44   | 16.8           |

† Average flux value

TABLE V

| Effect of Miglyol® 840 on Penetration of Atenolol Across Hairless Mouse Skin |               |  |                |
|--|---------------|--|----------------|
| Solvent System   | Percent (w/w) | Flux Value† ( $\mu\text{g}/\text{cm}^2/\text{h}$ ) | Lag Time (h)   |
| PG   | 4             | 38.39  | 22.4           |
| DPH:PG 50:50 w/w   | 4             | 148.7 $\pm$ 8.76                                   | 9.1 $\pm$ 2.2  |
| Miglyol® 840:ETOH 80:20 w/w  | 1             | 358.01 $\pm$ 29                                    | 0.5 $\pm$ 0.16 |

† Average flux value

## Claims

1.) A transmembranally administerable composition comprising:

- (a) about 0.2% to about 5% of therapeutically active medicament of bioaffecting agent,
- (b) up to about 99.8% of solvent, and, if desired,
- (c) up to about 15% of gelling agent.

2.) A composition of Claim 1 wherein the therapeutically active medicament bioaffecting agent is selected from the group consisting of diphenhydramine, tetrahydroaminoacridine, atenolol, taziflyline, 2-Methoxy-4-[2-(5-methyl-1H-pyrazol-3-yl)ethenyl] phenol or a pharmaceutically acceptable salt thereof.

3.) A composition of Claim 1 or 2 wherein the solvent is a mixture of propylene glycol diesters and/or triglycerides containing saturated plant fatty acids with a chain length of C<sub>8</sub> to C<sub>12</sub>.

4.) A composition of Claims 1 to 3 wherein the solvent is a propylene glycol diester of saturated vegetable fatty acids of chain length C<sub>8</sub> to C<sub>10</sub> (Miglyol® 840).

5.) A composition of Claims 1 to 43 wherein the gelling agent is a silicic acid as Aerosil® 200.

6.) A process for manufacturing a transmembranally administerable pharmaceutical composition characterized in that about 0.2% to about 5% of a therapeutically active medicament of bioaffecting activity is combined with up to about 99.8 weight% of a solvent and, if desired, with up to about 15% of a gelling agent.

Claims for the following Contracting States: GR, ES

1.) A process for manufacturing a transmembranally administerable pharmaceutical composition characterized in that about 0.2% to about 5% of a therapeutically active medicament of bioaffecting activity is combined with up to about 99.8 weight% of a solvent and, if desired, with up to about 15% of a gelling agent.

5 2.) A process of Claim 1, wherein the therapeutically active medicament bioaffecting agent is selected from the group consisting of diphenhydramine, tetrahydroaminoacridine, atenolol, tazifylline, 2-Methoxy-4-[2-(5-methyl-1H-pyrazol-3-yl)ethenyl] phenol or a pharmaceutically acceptable salt thereof.

3.) A process of Claims 1 and 2, wherein the solvent is a mixture of propylene glycol diesters and/or triglycerides containing saturated plant fatty acids with a chain length of C<sub>8</sub> to C<sub>12</sub>.

10 4.) A process of Claims 1 to 3, wherein the solvent is a propylene glycol diester of saturated vegetable fatty acids of chain length C<sub>8</sub> to C<sub>10</sub> (Miglyol ® 840).

5.) A process of Claims 1 to 4, wherein the gelling agent is silicic acid as Aerosil 200 ®.

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